Shrub dynamics in pre- and post-encroachment phases of grassland-to-shrubland transition

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INTRODUCTION

- Shrub dynamics during woody plant encroachment are likely mediated by belowground resources and contrasting root architectures.
- In the grassland state, competition with abundant grasses could slow shrub growth to adult life history stages (Fig.1A).
- In the shrubland state, maximum woody cover may depend on the intensity of density-dependent intraspecific interactions (Fig. 1B).
- We tested these hypotheses by conducting selective removal (SR) experiments along a *Bouteloua eriopoda* grassland – *Prosopis glandulosa* shrubland transition at the Jornada Basin LTER site in the Chihuahuan Desert.

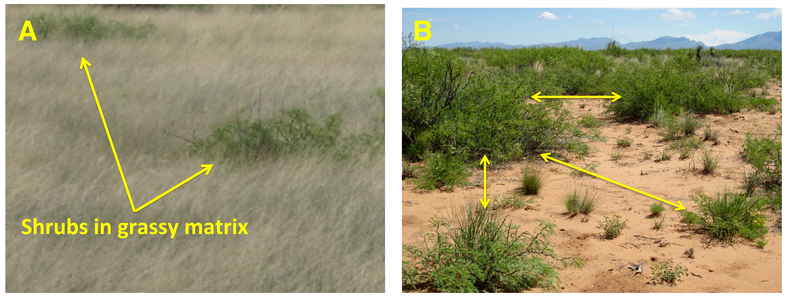

Figure 1: *P. glandulosa* shrubs have shallow lateral root systems that extend into zones dominated grasses whose roots are concentrated in the upper 40 cm of the soil (A) or zones where overlap with lateral root systems of conspecific shrubs may occur (B)[1]. Does this overlap in belowground spatial niche influence grass-shrub and shrub-shrub dynamics?

METHODS

- In SR1, focal *P. glandulosa* shrubs had their immediate (3x canopy diameter) *B. eriopoda* grass neighborhoods left intact (controls) or neutralized.
- In SR2, *P. glandulosa* shrubs within 5 m of a conspecific focal individual were left intact (controls) or killed (foliar herbicide.
- Target shrub aboveground net primary productivity (ANPP) was estimated at peak biomass (Sept.-Oct.) in SR1 and SR2 using species- and site-specific allometric equations[2].

RESULTS

- The ANPP response of small shrubs (< 50 cm diameter) to grass removal was positive and linear, but only in years with above-average growing season rainfall (Fig.2, solid lines).
- Larger shrubs showed no response to grass removal, regardless of growing season precipitation (Fig.2, dashed lines).

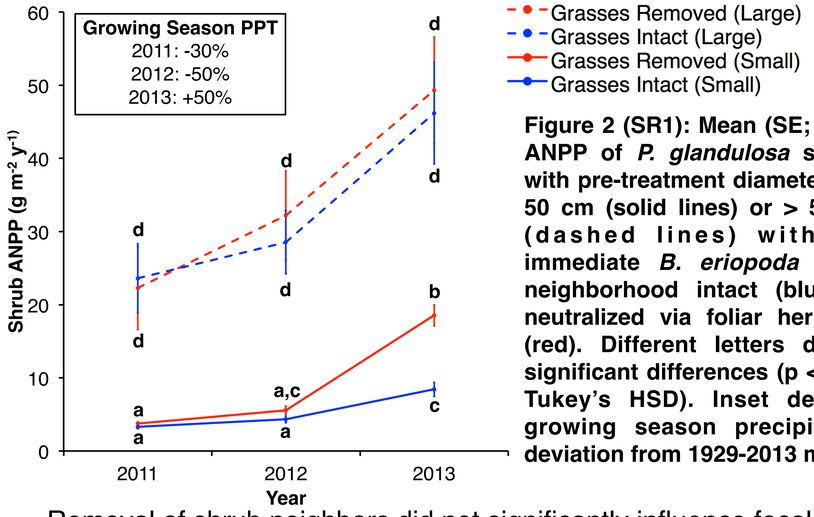

Figure 2 (SR1): Mean (SE; n=30) ANPP of *P. glandulosa* shrubs with pre-treatment diameter of < 50 cm (solid lines) or > 50 cm (dashed lines) with the immediate *B. eriopoda* grass neighborhood intact (blue) or neutralized via foliar herbicide (red). Different letters denote significant differences ($p < 0.05$, Tukey's HSD). Inset denotes growing season precipitation deviation from 1929-2013 mean.

- Removal of shrub neighbors did not significantly influence focal shrub ANPP relative to controls in any year (Fig.3A).
- No relationship exists between focal shrub ANPP and the cumulative aboveground biomass of conspecific shrubs within 5m (Fig.3B).

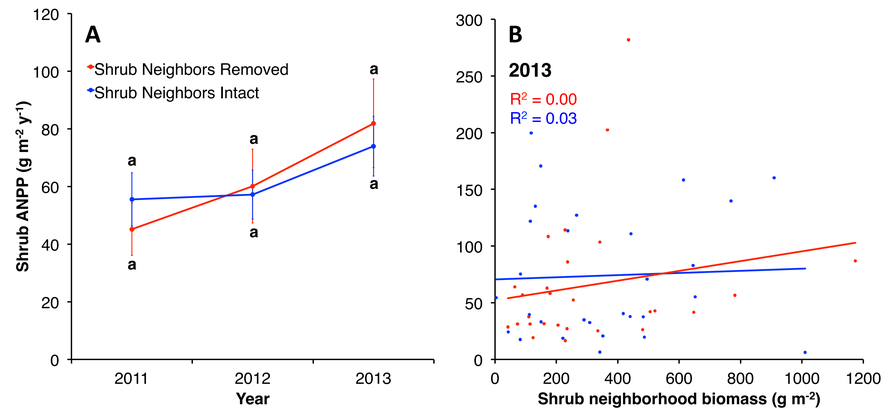

Figure 3 (SR2): (A) Mean (SE; n=30) ANPP of target *P. glandulosa* shrubs with conspecific neighbors within 5m intact (blue) or killed via herbicide (red). (B) Focal shrub ANPP in 2013 vs. total biomass of all shrubs within 5m at the start of the experiment. No statistically significant differences were observed.

CONCLUSIONS

- Results from SR1 indicate that when rainfall is above average, ANPP of small shrubs is suppressed by grasses, consistent with rainfall manipulation experiments at JRN[2,3].
- When grasses are abundant, the time required for small shrubs to attain a stature that can modify the physical environment in self-promoting ways[4-5] would be extended. Reductions in grass biomass (e.g. by drought or grazing) would ostensibly hasten grassland-to-shrubland transition.
- Lack of significant differences between treatments in SR2 suggests that maximum shrub cover may be more a function of constraints on plant size than on density-dependent interactions.
- Intraspecific interactions among larger shrubs may operate on time scales longer than this experiment

REFERENCES

1. Gibbens RP, Lenz JM. 2001. *Journal of Arid Environments* 49, 221-263.
2. Gherardi LA, Sala OE. In Press. *Proceedings of the National Academy of Sciences*.
3. Reichmann LG, et al. 2013. *Ecology* 94, 435-443.
4. Schlesinger WH, et al. 1990. *Science* 247, 1043-1048.
5. Li J, et al. 2007. *Biogeochemistry* 85, 317-322.

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